1a) $R = \frac{1}{\gamma} \cdot \frac{l}{A} (1 + \alpha \cdot \Delta T)$

$R_0 = \frac{1}{\gamma} \cdot \frac{l}{A} = \frac{1}{57 \cdot 10^6 \frac{S}{m}} \cdot \frac{20 \cdot 10^3 m}{\pi \cdot (\frac{10}{2} \cdot 10^{-3})^2 m^2} = 4,467 \Omega$

Winter $-20°C$; $R = R_0 \cdot (1 + \alpha \cdot (T - T_0))$

$= 4,467 \Omega \cdot (1 + 0,0004 \frac{1}{°C} \cdot (-20°C - 20°C))$

$= 3,752 \Omega$

Normal/Bezugstemperatur $20°C$ $R = R_0 = 4,467 \Omega$

Sommer $+40°C$ $R = 4,925 \Omega$

1 Punkt pro richtigem Wert
Σ 3 Pkt

b) $I = 40 A$ Spannungsabfall?

$\Delta U = R \cdot I$

Winter $-20°C$; $\Delta U = 3,752 \Omega \cdot 40 A = 150 V$

Normal $\Delta U = 179 V$

Sommer $\Delta U = 193 V$

Σ 3 Pkt

c) Verlustleistung $P = \Delta U \cdot I = R \cdot I^2$

Winter $P_V = 6 kW$

Normal $P_V = 7,154 kW$

Sommer $P_V = 7,724 kW$

Σ 3 Pkt

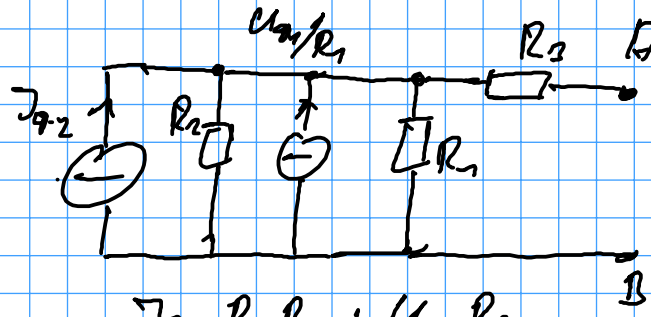
d) Im Sommer 1,724 kW mehr @ 24 h

$W = 1,724 kW \cdot 24 h = 41,376 kWh = 149 MJ$

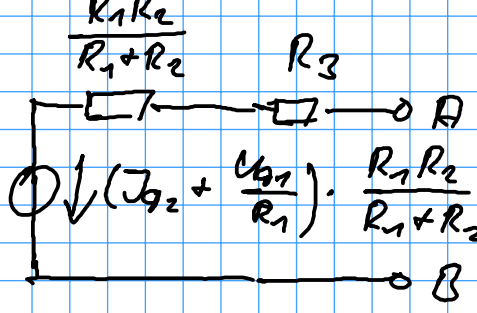
(2 Punkte)

2 Ersatzspannungsquelle

Linke Seite



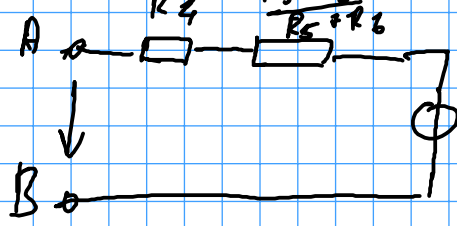
$\Rightarrow$



$$U_{LLL} = \frac{J_{q_2} R_1 R_2 + U_{q_1} R_2}{R_1 + R_2} \quad (1) \qquad ; \quad R_i = \frac{R_1 R_2}{R_1+R_2} + R_3 = \frac{R_1 R_2 + R_1 R_3 + R_2 R_3}{R_1 + R_2} \quad (1)$$

$$J_{KSZ} = \frac{U_{LLL}}{R_i} = \frac{J_{q_2} R_1 R_2 + U_{q_1} R_2}{R_1 R_2 + R_1 R_3 + R_2 R_3} \quad (1)$$

Rechts:

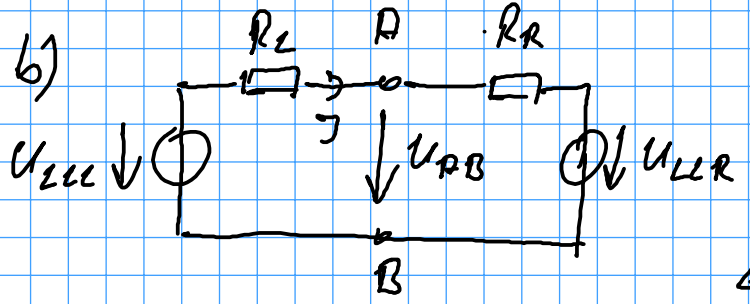


$$U_{LLR} = U_{q_2} \quad (1)$$

$$R_R = R_4 + \frac{R_5 R_6}{R_5+R_6} = \frac{R_4 R_5 + R_4 R_6 + R_5 R_6}{R_5 + R_6} \quad (1)$$

$$J_{KSR} = \frac{U_{LLR}}{R_R} = \frac{U_{q_2}(R_5+R_6)}{R_4 R_5 + R_4 R_6 + R_5 R_6} \quad (1)$$

b)



Maschensatz:

$$J \cdot R_L + J \cdot R_R + U_{LLR} - U_{LLL} = 0$$

$$\Rightarrow J = \frac{U_{LLL} - U_{LLR}}{R_L + R_R} \quad (2)$$

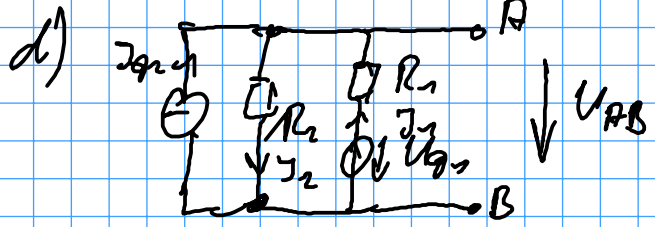
$$U_{AB} = U_{LLL} - R_L \cdot J = U_{LLL} - R_L \cdot \frac{U_{LLL} - U_{LLR}}{R_L + R_R} = \frac{U_{LLL} \cdot R_L + U_{LLR} R_R}{R_L + R_R} \quad (2)$$

c) Strom durch R_3 ist Null

$\Rightarrow$ Kein Strom durch R_3, R_4, R_5, R_6 (1)

$J_3 = J_R = 0 \qquad U_{LLL} = U_{LLR} = U_{q_2} = \frac{J_{q_2} R_1 R_2 + U_{q_1} R_2}{R_1 + R_2}$ (1)

d)



(3 Pkt)

e) Nur U_{q1} eingeschaltet

$$I_{21} = I_{11} = \frac{U_{q1}}{R_1 + R_2}$$

$$I_{12} = -I_{q2} \cdot \frac{R_2}{R_1 + R_2} \qquad I_{22} = I_{q2} \cdot \frac{R_1}{R_1 + R_2}$$

$$I_1 = I_{11} + I_{12} = \frac{U_{q1} - I_{q2} R_2}{R_1 + R_2} \quad (1)$$

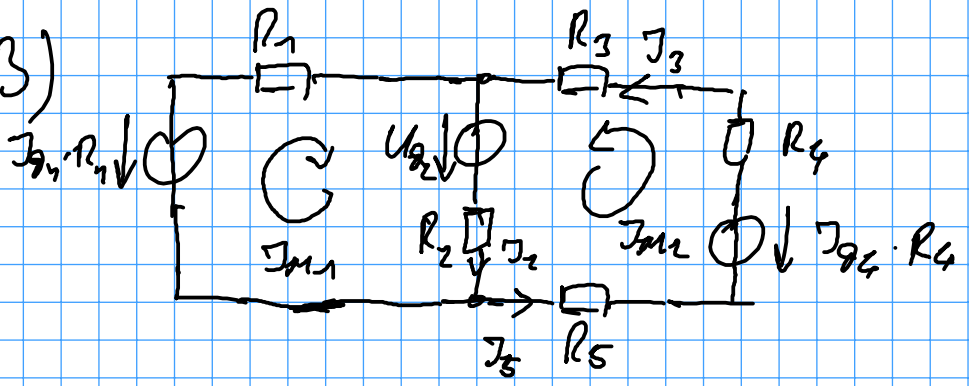
$$I_2 = I_{21} + I_{22} = \frac{U_{q1} + I_{q2} R_1}{R_1 + R_2} \quad (1)$$

$$P_{R1} = R_1 \cdot I_1^2 = R_1 \cdot \left(\frac{U_{q1} - I_{q2} R_2}{R_1 + R_2}\right)^2 \quad (1)$$

$$P_{R2} = R_2 I_2^2 = R_2 \cdot \left(\frac{U_{q1} + I_{q2} R_1}{R_1 + R_2}\right)^2 \quad (1)$$

$$P_{ges} = P_{R1} + P_{R2} = R_1 \left(\frac{U_{q1} - I_{q2} R_2}{R_1 + R_2}\right)^2 + R_2 \left(\frac{U_{q1} + I_{q2} R_1}{R_1 + R_2}\right)^2 \quad (1)$$

3)



GLS: $\begin{pmatrix} R_1+R_2 & R_2 \\ R_2 & R_2+R_3+R_4+R_5 \end{pmatrix} \begin{pmatrix} J_{m1} \\ J_{m2} \end{pmatrix} = \begin{pmatrix} J_{q1}R_1 - U_{q2} \\ J_{q4}R_4 - U_{q2} \end{pmatrix}$ 5 Pkt

b) Cramer'sche Regel

$$J_{m1} = \frac{(J_{q1}R_1 - U_{q2})(R_2+R_3+R_4+R_5) - (J_{q4}R_4 - U_{q2})R_2}{(R_1+R_2)(R_2+R_3+R_4+R_5) - R_2^2} \quad (2)$$

$$J_{m2} = \frac{(J_{q4}R_4 - U_{q2})(R_1+R_2) - (J_{q1}R_1 - U_{q2})R_2}{(R_1+R_2)(R_2+R_3+R_4+R_5) - R_2^2} \quad (2)$$

c) Zweigströme

R_1: $J_1 = J_{q1} - J_{m1}$

R_2: $J_2 = J_{m1} + J_{m2}$ (5)

R_3: $J_3 = J_{m2}$

R_4: $J_4 = J_{q4} - J_{m2}$

R_5: $J_5 = -J_{m2}$

d)

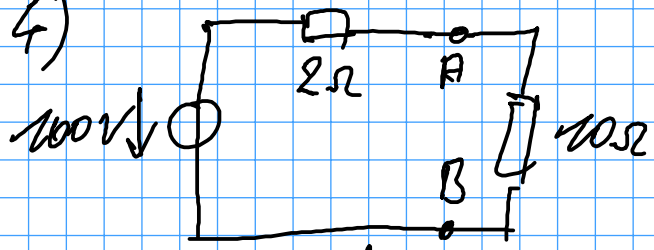
$$\begin{pmatrix} 1010 & 10 \\ 10 & 1012 \end{pmatrix} \begin{pmatrix} J_{m1} \\ J_{m2} \end{pmatrix} = \begin{pmatrix} 0 \\ 10 \end{pmatrix} \text{A}$$

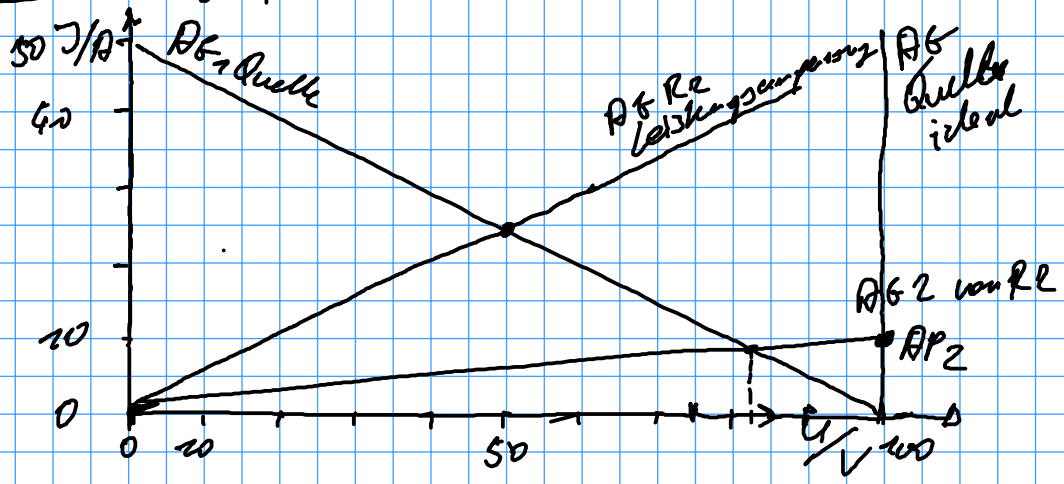
$J_{m1} = -97{,}8\,\text{mA}$; $J_{m2} = 9{,}88\,\text{mA}$ (5)

$J_1 = 1{,}0098\,\text{mA}$; $J_2 = 9{,}928\,\text{mA}$

$J_4 = 1{,}012\,\text{mA}$; $J_3 = J_5 = 9{,}88\,\text{mA}$

4)





b) ΔP_1: $U = 83{,}3\,V$; $J = 8{,}33\,A$ (2)

c) ΔP_2: $U = 100\,V$; $J = 10\,A$ (2)

d) Leistungsanpassung $U_{R_1} = U_{R_2} = \frac{1}{2} U_0$

ΔP: $U = 50\,V$; $J = 25\,A$; $R_1 = R_2 = 2\,\Omega$ (3)

e) Wirkungsgrade

1) $\eta = \frac{J^2 \cdot R_2}{J^2 \cdot (R_1 + R_2)} = \frac{10}{12} = 83{,}3\,\%$

2) $\eta = 100\,\%$

3) $\eta = 50\,\%$

(3)